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H5H H109 H126 H155 H175 H198 H199 H200 H231 H234 H251
U1S S1953

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GB 1524071 A GB 1460929 A GB 1176651 A
GB 0612202 A EP 0282805 A US 4868899 A
US 4659056 A

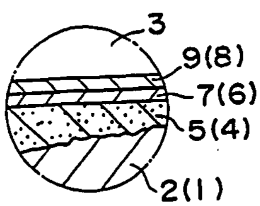
(58) Field of search
UK CL (Edition K) B5A AD24A AD24S, H5H HAL HAX2 HBF2 HBF3 HBG2 HBG3
INT CL[5] B29C

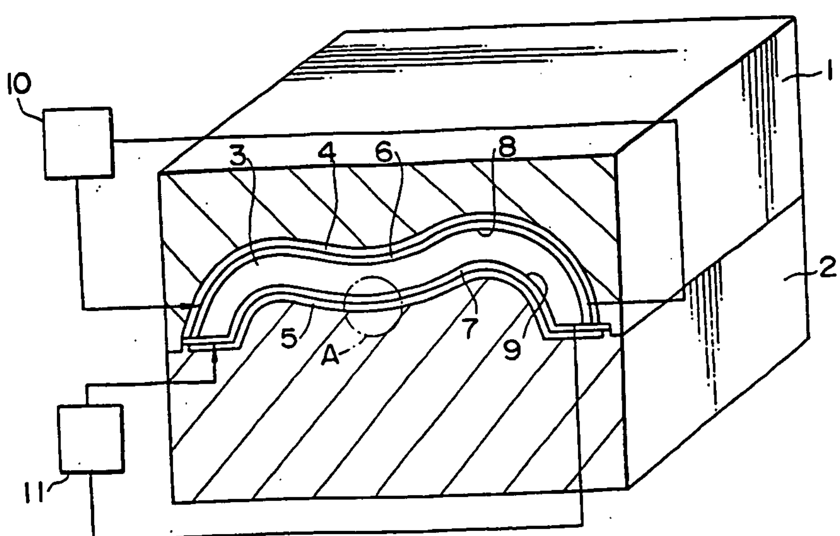
(54) Electrically heated moulding die

(57) A die for injection or compression moulding or thermoforming of plastic materials, comprises a die body strength member (1, 2), heat insulating layers (4, 5) of an insulating material, heating layers (6, 7) of electrically conductive material provided on the cavity side of the heat insulating layers, and protective layers (8, 9) of abrasion-resisting material provided on the cavity side surface of the heating layers. The die body material may be soft-steel, or chrome-molybdenum or tool steel. The heat insulating layer material may be of glass powder, zirconia, or alumina. The heating layer material may be Ni-P, nichrome, TiN, TiC. The protective layer material may be of Cr, TiN, or TiC, of greater electrical resistance and better heat conductivity respectively, than the heating and insulating layers. The materials may be inclined (Fig 3) in each layer to prevent peeling and heat cracking. A plurality of separately heating systems may be provided with localised control/ thermocouples.

FIG. 1

FIG. 3





At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

FIG. 1

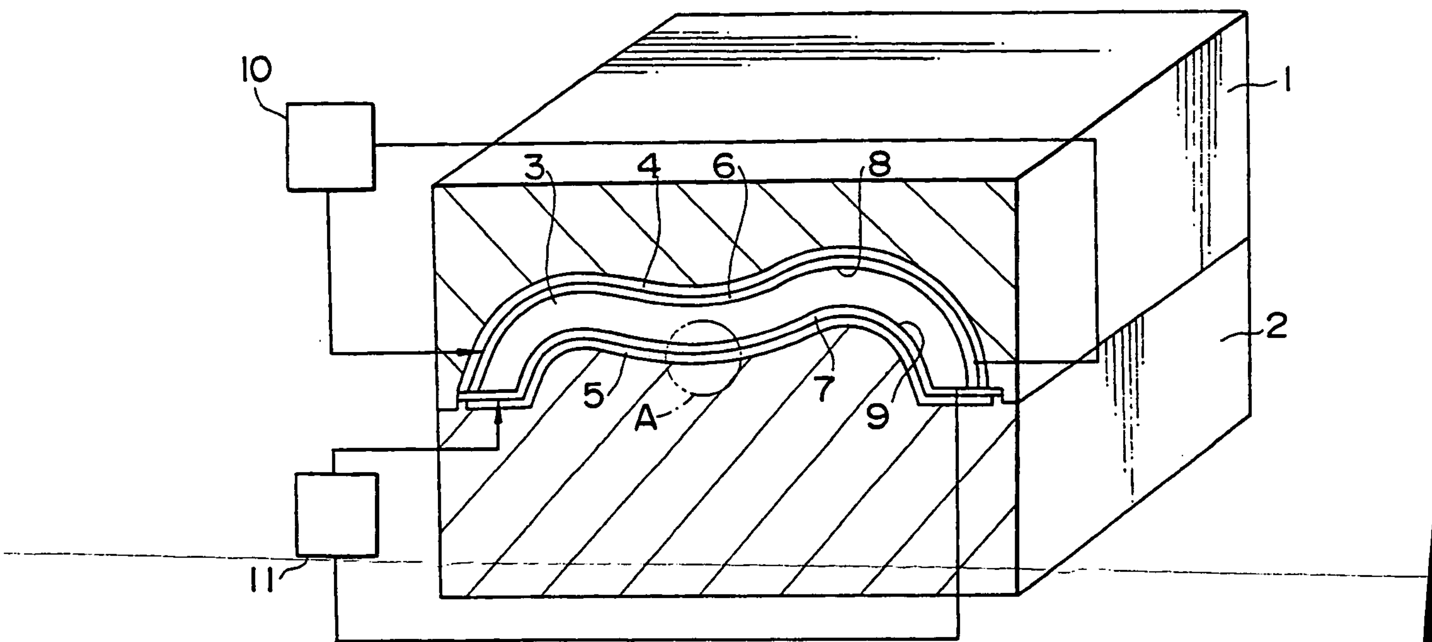


FIG. 2

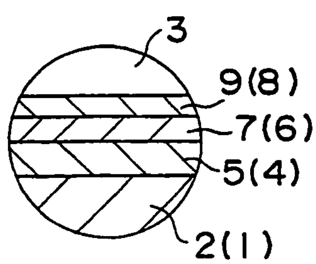
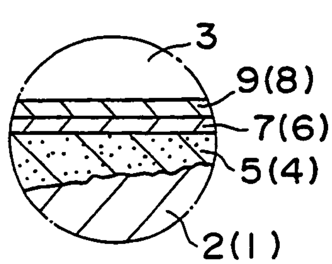
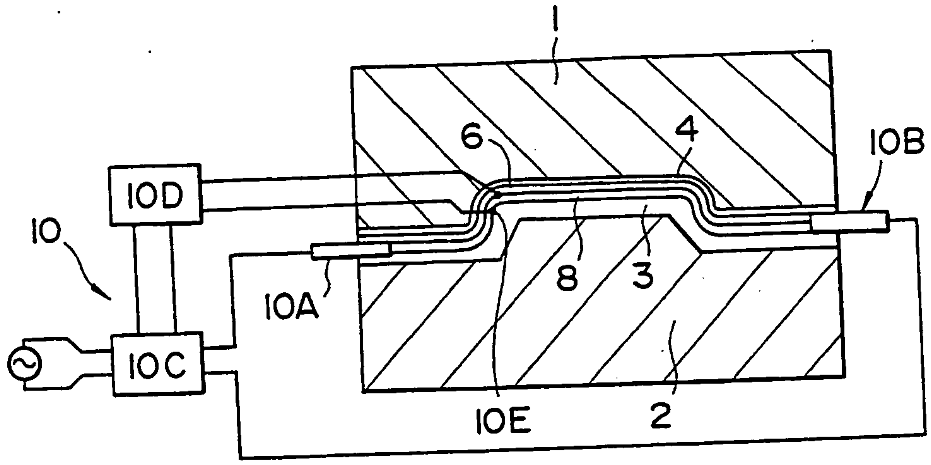


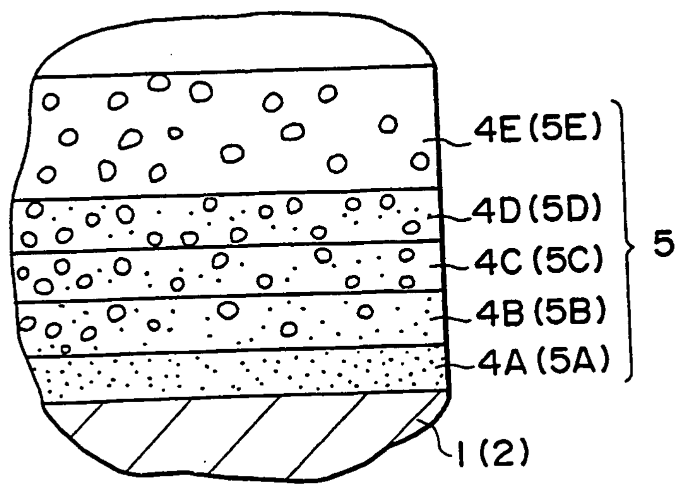
FIG. 3



F I G. 4



F I G. 5



TITLE OF THE INVENTION:

MOLDING DIE

BACKGROUND OF THE INVENTION:

Field of the Invention:

The present invention relates to a molding die for use in injection molding, compression molding, and thermoforming of plastic materials.

Description of the Prior Art:

In injection molding, a plastic material that has been heated and plasticized is forced into a die which is at a lower temperature than the material, and then set by further cooling the die.

However, in a lower-temperature part of this injection molding die, the molten resin increases in viscosity, becoming of less fluidity, and therefore it becomes necessary to apply a high pressure (e.g. a pressure of ~1600 atm) for filling the cavity of the die with the molten resin and to maintain this high pressure for a certain period of time.

Ideal injection molding may be accomplished if the die inner surface is maintained at the same temperature as the plastic material from the beginning of

injection until the filling of the die cavity, and also if after thus filling, the die is rapidly cooled to set and mold the material. Practically, however, it is impossible to rapidly heat and cool only the inner surface of the die because of a great heat capacity of the die.

In prior-art molding dies, as has been disclosed in Laid-Open Japanese Patent Application No. 60-174624, there has been proposed a molding die provided with heating means on or near a surface facing the cavity of the die.

The prior-art molding die state in the above-mentioned Japanese patent official journal has such advantages as improved quality of moldings and reduced molding cycle. However, since it is of a so-called two-layer structure consisting of a copper film as a conductive film for supplying the electricity for heating the plastic material and a ceramic insulating layer used between this conductive film and the die, there still exists such a problem that the conductive film is liable to abrasion and otherwise damage resulting from repetition of injection molding.

SUMMARY OF THE INVENTION:

This invention has been accomplished in an attempt to solve the above-mentioned problems and has as its object the provision of a molding die having heating means lined on or near a surface of the die facing a cavity. The die is a so-called three-layer structure consisting of a heat-insulating layer, a heating layer, and a protective film layer, so that the die has high abrasion resistance and great durability to repeated injection molding operation and further is usable with a low injection pressure, e.g. a pressure of less than 200 atm, while maintaining the usability of the above-described prior art.

This invention has the following technical means for attaining the aforesaid object.

The molding die according to this invention is provided, on the inner surface facing the cavity 3 of the dies 1 and 2 made of a strength member, heat insulating layers 4 and 5 made of an insulating member, heating layers 6 and 7 made of a conductive member on the upper surface of the heat insulating layers 4 and 5, and protective film layers 8 and 9 made of abrasion-resisting member on the upper surface of the heating layers 6 and 7.

This invention and its features and advantages will be set forth and become more apparent in the detailed description of the preferred embodiments presented below.

BRIEF DESCRIPTION OF THE DRAWINGS:

The drawings show preferred embodiments according to this invention, wherein:

Fig. 1 is a sectional perspective view showing a die for an injection molding machine;

Fig. 2 is an enlarged view of A section in Fig. 1;

Fig. 3 is an enlarged view showing another embodiment of Fig. 2;

Fig. 4 is a sectional view showing another embodiment of Fig. 1; and

Fig. 5 is an enlarged view showing another embodiment of Fig. 3.

DESCRIPTION OF THE PREFERRED EMBODIMENTS AND FUNCTION:

Hereinafter exemplary embodiments and function of a molding die according to this invention will be described with reference to the accompanying drawings.

Fig. 1 is a sectional perspective view showing a molding die in an injection molding machine. The die

consists of a first half 1 and a second half 2 for injection molding. A cavity 3 is defined by these first and second halves 1 and 2 of the die.

A base material of the first and second halves 1 and 2 is produced of such strength members as soft steel, chrome-molybdenum steel, and tool steel. The cavity 3 communicates with a sprue which is not illustrated, to which an injection nozzle is connected.

The inner surfaces of the first and second halves of the die defining the cavity 3 has heat insulating layers 4 and 5 made of an insulating member, heating layers 6 and 7 made of a conductive member on these heat insulating layers 4 and 5, and protective film layers 8 and 9 made of abrasion-resisting member on the heating layers 6 and 7. To the heating layers 6 and 7 are connected control circuits 10 and 11 which enable the application of a specific voltage.

In Fig. 2 ceramic materials such as glass powder, zirconia, alumina, etc. are adopted for the heat insulating layers 4 and 5, which are several 100 μm thick.

Concretely speaking, glass-powder heat insulating layers are produced by baking for enameling the glass powder applied on the base metal; zirconia heat

insulating layers are produced through flame spraying and HIP treatment of zirconia; when only flame spraying is done, a zirconia layer thus produced has a porous structure; and alumina heat insulating layers are produced by sputtering or flame spraying alumina. The zirconia layer can be provided with little heat conductivity and thermal expansivity close to that of steel. Also, when alumina is adopted, a layer having great hardness can be formed.

For the heating layers 6 and 7 is adopted such a conductive member of little electrical resistance as Ni-P, nichrome, TiN, TiC, etc., measuring several 10 μm to 100 μm in thickness.

Concretely, Ni-P layers are produced by an electroless plating means, nichrome layers are provided by an HIP treatment, and TiN and TiC layers are formed through physical vapor deposition (PVD) and chemical vapor deposition (CVD), each measuring 5 to 20 μm in thickness.

Thin films or sheets of a specific thickness made of other ductile metallic materials can be produced by explosive cladding when used as heating layers.

The protective film layers 8 and 9 are produced of such abrasion-resisting materials as Cr, TiN and TiC

having a better heat conductivity than the heat insulating layers 4 and 5 and a greater electrical resistance than the heating layers 6 and 7, each having the thickness of several 10 μm.

Concretely, Cr protective film layers are produced by an electrolytic plating means, and TiN and TiC layers are produced through PVD and CVD. When TiN and TiC protective film layers 8 and 9 are used, the heating layers 6 and 7 are Ni-P or nichrome layers; no TiN and TiC layers will be adopted.

In performing injection molding by the use of the die halves 1 and 2 constituted as described above, a specific voltage is applied through the control circuits 10 and 11 and the heating layers 6 and 7 consisting of conductive members are set at nearly the same temperature as the heating-transforming temperature of a material to be molded. Upon the application of the voltage, the temperature of the heating layers 6 and 7 rises instantly and therefore the use of this die is effective for reducing the molding cycle. Further, as the heat insulating layers 4 and 5 are provided between the heating layers 6 and 7 and the halves 1 and 2 of the die, there is little fear of current leakage and besides the heating layers 6 and 7 can be maintained at a uniform

temperature without being deprived of heat by the die halves 1 and 2.

Furthermore the heating layers 6 and 7, having the protective film layers 8 and 9 of abrasion-resisting member on the upper surface, are protected from abrasion and spalling likely to occur in repeated injection molding.

Next, an injection molding cycle time will be explained. In the injection molding, one cycle of molding operation consists of an injection start time t1, an injection end time t2, a cooling start time t3, a cooling end time t4, and a molding ejection time t5.

Between the time t1 and the time t2, a thermoplastic material is injected from an injection nozzle into the cavity 3 through the sprue.

At this time, the material to be molded is heated and plasticized by the surface of the cavity 3, that is, by the heating layers 6 and 7 which are hot, and is filled in the cavity 3 without being deprived of heat by the first and second halves 1 and 2 of the die. It is, therefore, possible to obtain quality molded articles by setting the die halves 1 and 2 at a low temperature and also by setting the cavity 3 surface alone at a high temperature at which well-balanced molded articles can be

obtained without molding shrinkage. At the time t2 the voltage applied to the heating layers 6 and 7 is released by the control circuits 10 and 11. Therefore the heating layers 6 and 7, being of little heating capacity as compared with the whole of the die halves 1 and 2, are instantly cooled to a temperature nearly equal to the temperature of the halves 1 and 2 of the die preset to a plastic material setting temperature.

During the period between the time t3 and the time t4, the thermoplastic material injected into the cavity 3 formed by the halves 1 and 2 of the die is cooled and set therein into a form of molded article.

Further, during the period from the time t4 and the time t5, the halves 1 and 2 of the die are opened and a molded article is ejected. Thereafter the control circuits 10 and 11 are operated to apply the voltage again to the heating layers 6 and 7 in order to raise the surface temperature of the cavity 3, thus repeating the above-described operation.

The molding cycle can be decreased by instantly raising and lowering the surface temperature of the cavity 3 as described above. And during the period from the injection start time to the injection end time, the surface temperature of the cavity 3 is kept up to the

material melting temperature, thereby maintaining balanced molding shrinkage of the thermoplastic material to produce quality molded articles.

In Fig. 3, there is disclosed a means for preventing peeling and cracking by a difference in thermal expansion of molded articles by the use of inclined component materials through the whole or a part of layers in an interface between the base metal of the halves 1 and 2 of the die and the heat insulating layers 4 and 5, in an interface between the heat insulating layers 4 and 5 and the heating layers 6 and 7, and an interface between the heating layers 6 and 7 and the protective film layers 8 and 9.

Fig. 4 shows another preferred embodiment of a means (a control circuit) for supplying the electric current to the heating layers. In this drawing is shown the upper half 1 of the die consisting of the heat insulating layer 4, the heating layer 6 and the protective layer 8.

The control circuit 10 shown in Fig. 4 is designed to control the supply of heating current from a thyristor 10C through electrodes 10A and 10B to the heating layer (a heater member) 6 which is separated into two to three systems preferably independently in the

direction of cavity surface. In this case, there is preferably provided a temperature control unit 10D for measuring temperature at specific points of the die 1 by use of a thermocouple 10E by each section, thereby enabling local temperature control of the die.

In addition, in order to check uniform heating of the die inner surface and to improve heating performance, it is possible to mount the electrodes 10A and 10B in the optimum mounting condition by monitoring, with a scanning infrared temperature gage, temperature distribution in the inner surface of the die, by supplying the electric current through the thyristor 10C with the halves 1 and 2 of the die opened.

Fig. 5 shows a more preferred embodiment of the inclined component material.

As the heat insulation layers 4 and 5 are most liable to peel off from the halves 1 and 2 of the die produced of a strength member, the heat insulating layers 4 and 5 produced of zirconia, or preferably partly stabilized zirconia, are used on the surface of the halves 1 and 2 of the die produced of such a strength member as steel, CrMo steel, etc..

In this case, the heat insulating layers 4 and 5 formed on the inner surfaces of the die by flame

spraying consist of first layers 4A and 5A of 100 weight percent of steel powder, second layers 4B and 5B of 75 weight percent of steel powder and 25 weight percent of zirconia, third layers 4C and 5C of 50 weight percent of steel powder and 50 weight percent of zirconia, fourth layers 4D and 5D of 25 weight percent of steel powder and 75 weight percent of zirconia, and fifth layers 4E and 5E of 100 weight percent of zirconia, the thickness of the fifth layers 4E and 5E being 50 to 20 μm and the thickness of the other layers, that is, the first to fourth layers, being 10 to 30 μm, thereby improving workability.

The flame spraying to be adopted is preferably a vacuum plasma spray process which produces a coating of lower porosity, and also it is desirable to perform HIP treatment after flame spraying for the purpose of obtaining dense layers.

Further, it is allowed to provide a die cooling medium passage in a part facing the cavity 3 of the die halves 1 and 2.

According to the present invention, it is possible to provide molding dies having great durability which are able to produce higher-quality molded articles in a short molding cycle while effectively controlling

the injection pressure.

This invention has been described in detail with particular reference to preferred embodiments thereof but it will be understood that variations and modifications can be effected within the spirit and scope of the invention.

WHAT IS CLAIMED IS:

1. A molding die, comprising at least:

a die body having a cavity and consisting of a strength member,

heat insulating layers produced of an insulating member,

heating layers produced of conductive members provided on the upper surface of said heat insulating layers, and

protective film layers produced of an abrasion-resisting member provided on the upper surface of said heating layers.

2. A molding die as claimed in claim 1, wherein said protective film layers are produced of an abrasion-resisting member having a great heat conductivity than said heat insulating layers and a greater electric resistance than said heating layers.

3. A molding die as claimed in claim 1, wherein said heat insulating layers are produced of an inclined component member which decreases in the amount of a specific insulating member as it goes from the inner surface of said cavity towards said heating layers.

4. A molding die as claimed in claim 1, wherein said heating layers are provided with a control circuit

which are separated into at least two independent systems in the direction of the inner surface of said cavity for supplying the heating current to said systems respectively.

5. A molding die as claimed in claim 1, wherein said protective film layers are produced of at least one kind selected from among Cr, TiN and TiC.

6. A molding die as claimed in claim 1, wherein interfaces of said heat insulating layers, said heating layers and said protective film layers are produced of an inclined component material through at least a part of said layers.

~~7. A moulding die substantially as hereinbefore described~~ with reference to and as shown in the accompanying drawings.

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~~Pa~~tents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number	9114891.6
Search Examiner	A J M TAJASQUE
Date of Search	10 OCTOBER 1991

Relevant Technical fields

(i) UK Cl (Edition K) B5A: AD24A; AD24S
H5H, HAL, HAX2, HBG2, HBG3, HBF2, HBF3.

(ii) Int Cl (Edition 5) B29L

Databases (see over)

(i) UK Patent Office

(ii)

Documents considered relevant following a search in respect of claims 1 TO 7

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	GB A 1524071 (B U S M) - page 2, lines 66-79; Examples 1 and 2; page 10, lines 19-34	Claim at lea
X	GB A 1460929 (SCHLOEMANN) - page 2, lines 26-51	" "
X	GB A 1176651 (P EISLER) - page 3, lines 112-116; page 5, lines 7-73; figures 12 and 14	" "
X	GB A 0612202 (GORDON & OTHRI) - whole disclosure	" "
X	EP A 0282805 (GEN ELECT) - figures 3 and 4; column 2, lines 31-47; layers 60, 62, 64, 66	" "
X	US 4868899 (BUCHTAL) - figure 3; column 3, lines 16-32	3 and
X	US 4659056 (S N I et A) - figures 4-6	Claim at lea

1tp - c:\wp51\doc99\fil000063

SF2(p)

Category	Identity of document and relevant passages	Rele .t to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

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P: Document published on or after the declared priority date but before the filing date of the present application.

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